國立中央大學109學年度碩士班考試入學試題

所別： 化學工程與材料工程學系 碩士班 甲組(一般生)　　共3頁 第1頁

科目： 輸送現象與單元操作

本科考試可使用計算器，廠牌、功能不拘　　＊請在答案卷(卡)內作答

This examination consists of six problems with a total possible score of 100%. Please show your work and related calculations, and clearly identify your answers in the examination answer booklet. You do not need to present your solutions in order, but you must label the problem number for your responses.

1. (12%) Near the surface of a flat plate, water has a velocity profile given by

$$u_x=3y-y^3 \qquad (1)$$

with y in mm, u_x in cm s^{-1}, and $0\le y\le 1$ mm (see Figure 1). The density and kinematic viscosity of water are 10^3 kg m^{-3} and 7×10^{-7} m^2s^{-1}, respectively.

(a) (4%) What is the shear stress at x_1 on the plate?

(b) (4%) What is the momentum flux at y=0.8 mm and $x=x_1$ in the y-direction?

(c) (4%) Is there momentum flux in the x-direction at y=0.8 mm and $x=x_1$ in the x-direction? If so, evaluate.

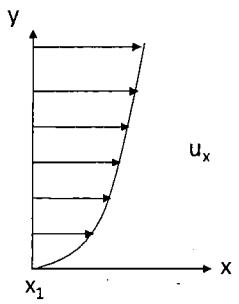


Figure 1

2. (18%) With either metallic or ceramic powders, it is important to separate homogeneous mixtures in the range of particles sizes from 10 to 250 μm. For this purpose we apply the principle of air elutriation, which is illustrated by the device shown in Figure 2. Figure 3 shows friction factors (f) as a function of Reynolds number (Re_D) for submerged bodies. The force exerted by the air stream is great enough to suspend particles of a given diameter, and all particles of smaller diameter are carried upward and to the collector of lines. Larger particles fall back against the air stream and down into a settling chamber. For the effective operation of this device it is necessary to know the size of particles suspended at a given

注意：背面有試題

flow rate. Assuming that a spherical particle, with a density of 4000 kg m^{-3}, applies to a homogeneous mixture of iron powder, draw a graph that relates the diameter of suspended particles to the velocity of the air in the expanded portion of the tube. For air at 300 K, the fluid properties are η (viscosity) = 1.80×10^{-5} kg $m^{-1}s^{-1}$ and ρ (density) = 1.18kg m^{-3}.

(a) (9 %) Please verify that Stokes' law applies, at least for particles with diameters up to 50 μm.

(b) (9 %) Calculate the terminal velocity for three sizes (10, 140 and 250 μm) of particles. For larger particles, Stokes' law is not valid.

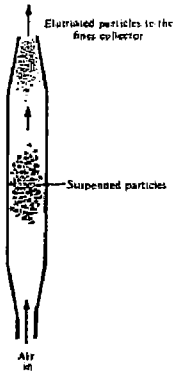


Figure 2.

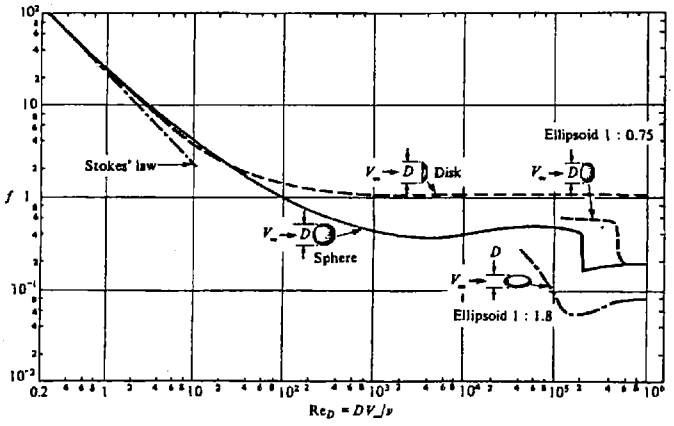
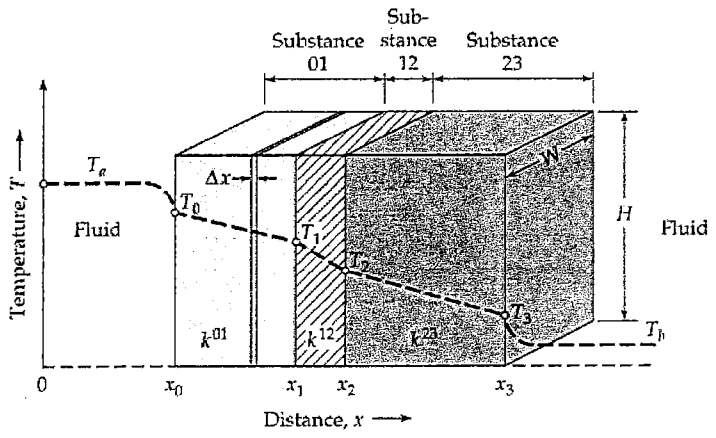


Figure 3 Friction factors for submerged bodies.

3. (12%)



For the above figure, please

國立中央大學109學年度碩士班考試入學試題

(a) (10%) derive the relationship for the overall heat transfer coefficient U in terms of the interface heat transfer coefficients h_0 at x = x_0 and h_3 at x = x_3, and different thermal conductivities k^{01}, k^{12}, and k^{23} of solid substances, and

(b) (2%) find which solid substance has the smallest thermal conductivity in the figure? Why?

4. (18%) A heated sphere of radius R is suspended in a large, motionless body of fluid. It is desired to study the heat conduction in the fluid surrounding the sphere in the absence of convection. The surface temperature of sphere is T_S, the temperature of infinite fluid is T_∞, and k is the thermal conductivity of fluid.

(a) (13%) Determine the temperature distribution of fluid.

(b) (5%) Find the relationship for predicting the Nusselt number.

5. (25%) A countercurrent absorption unit is used to reduce an acetone-air mixture containing 0.015 mole fraction of acetone to 1% of this value using water in a packed tower. The gas flowrate G' is 1 kg/m^{2}s of air and water enters at a rate of 1.6 kg/m^{2}s. In this system, Henry's law applies and $y_e = 1.75x$, where y_e is the mole fraction of acetone in the vapor at equilibrium with a mole fraction x in the liquid.

(a) (5%) Draw a schematic of this unit and clearly label the flows and known values.

(b) (10%) How many overall liquid transfer units N_{OL} are required to perform this operation?

(c) (10%) What is the corresponding number of overall gas transfer units N_{OG}?

6. (15%) To effect the separation of benzene from toluene, a total reflux distillation method is used. In this system, top product concentration $x_d = 0.9$, bottom product concentration $x_w = 0.1$, and feed concentration $x_f = 0.4$. The mean volatility of benzene versus toluene is assumed to be 2.4. How many theoretical plates are needed to perform this separation at total reflux?